Applications of genetic algorithms on fully-autonomous road networks

Sam Barrett, 1803086

University of Birmingham

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My Topic

- Semi-autonomous vehicles are becoming more prevalent
- Roads are becoming more congested with a 78% increase in motor traffic since 1993 [3]
- Fully autonomous vehicle trials have been legal in parts of the US since 2015[1], with the UK set to follow by next year (2021)[6]

- Much of the current research into autonomous vehicle routing focuses on semi-autonomous road networks
- By removing the human element and working on theoretical *fully autonomous road networks* we can make many useful assumptions about the behaviour of other vehicles
- The solution to road congestion is not to build bigger roads, it is to optimise the traffic flows.
- Just 78.2% of journeys on the UK Highway Agencies roads were *on time* in the year ending June 2014 [5]

- From a technical perspective, there are many things that need to be implemented to make such a system possible.
  - The functional representation of vehicle trajectories
  - The encoding of routes into a real-valued string of genes
  - The decoding of a real-valued string of genes to a route which a vehicle can take
  - The implementation of a function to determine the fitness of an individual route.
  - Implementation of genetic operators: Selection, crossover and mutation.
  - Cleanup operators to make certain any new individuals are valid

Practicality

In terms of near and long term practicality:

- Implementation of such a system would require a government mandate.
- All vehicles on the road wanting to use the motorway system would need to be fully autonomous and adhere to a strict standard
- This standard would need to stipulate required sensors and allow for a higher-level planning system to direct all vehicles in a network.

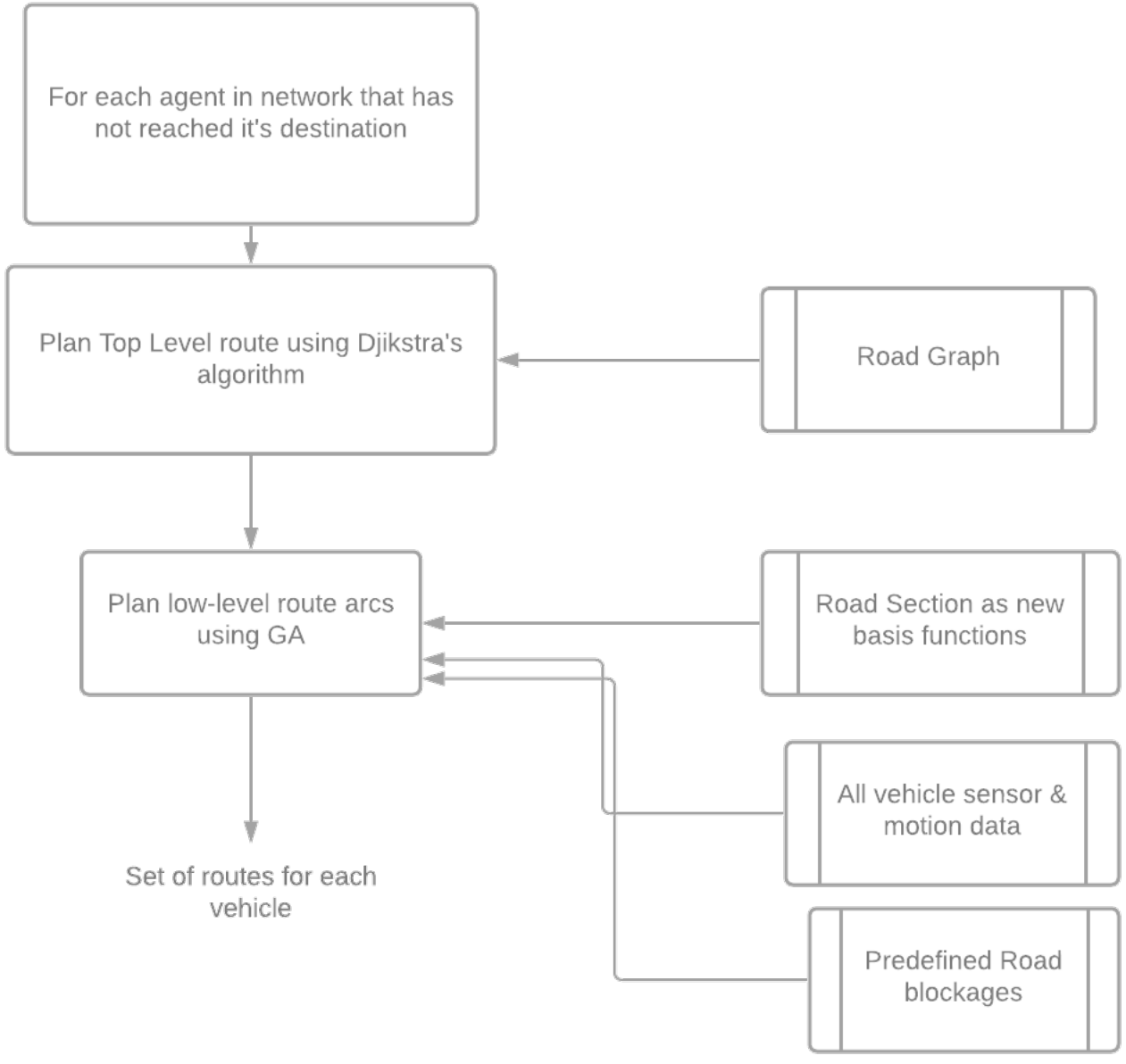

Figure: Abstract Project Topology

My Goal

My goal with this project is to investigate the feasibility of such a system.
To do so I will *programatically* implement an experimental version, making various assumptions about the data available to it.
With my system I hope to be able to run various simulations to determine it's performance in quasi real-world scenarios and conclude as to whether the use of GAs have merit in this area.
Currently the research yields no such results. The feasibility of similar systems have been discussed[4] but never experimentally investigated.

Methods

I have started by reading and collating papers, books and articles surrounding GAs and their applications on routing problems.
I have found substantial research into GAs but only a few papers on my sub-area, mainly by Rahul Kala from the Indian Institute of Information Technology.

I have begun implementing various utility functions and types in Julia[2], including:

- Bézier curve functions
- Road, Individual, Phenotype and Genotype types
- Plotting utilities for Roads and candidate solutions
- Population initialisation functions
- Genetic operators

Still to implement:

- Various different operators & performance comparisons between them
- Heuristics to further optimise the algorithm
- Cooperative route planning wrapper

Once a basic GA has been implemented, the stage of variable and operator refinement can begin.

There are many oppertunities for improvement of GAs with a wide variety of crossover and mutation techniques being discussed in literature, each performing differently depending on the search space.

One aim of my report will be to assess and collate the effectiveness of a wide variety of such operators, with the hope of concluding which are best for the task.
GAs can also be augmented via the use of domain-specific heuristics and as such I will investigate this area also

References I

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[2] The Julia Programming Language.
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[3] Highways England network journey time and traffic flow data.
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References II

[4] R. Kala.
On-Road Intelligent Vehicles: Motion Planning for Intelligent Transportation Systems / Rahul Kala.
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[6] Unknown.
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